

WE CLAIM:

1           1.    A giant magnetoresistive memory device  
2    comprising:  
3           a magnetic storage layer;  
4           a magnetic sense layer;  
5           a non-magnetic spacer layer between the  
6    magnetic sense layer and the magnetic storage layer; and,  
7           an antiferromagnetic layer formed in proximity  
8    to the magnetic storage layer whereby the  
9    antiferromagnetic layer couples magnetically in a  
10   controlled manner to the magnetic storage layer such that  
11   the magnetic storage layer has uniform and/or directional  
12   magnetization.

1           2.    The giant magnetoresistive memory device  
2    of claim 1 wherein the magnetic storage layer comprises a  
3    ferromagnetic alloy.

1           3.    The giant magnetoresistive memory device  
2    of claim 1 wherein the magnetic storage layer comprises  
3    ferromagnetic multilayers.

1           4.    The giant magnetoresistive memory device  
2 of claim 1 wherein the storage layer is between the non-  
3 magnetic spacer layer and the antiferromagnetic layer,  
4 and wherein the non-magnetic spacer layer is between the  
5 storage layer and the sense layer.

1           5.    The giant magnetoresistive memory device  
2 of claim 4 wherein the magnetic storage layer comprises a  
3 ferromagnetic alloy.

1           6.    The giant magnetoresistive memory device  
2 of claim 4 wherein the magnetic storage layer comprises  
3 ferromagnetic multilayers.

1           7.    The giant magnetoresistive memory device  
2 of claim 1 wherein the antiferromagnetic layer is between  
3 the non-magnetic spacer layer and the storage layer, and  
4 wherein the non-magnetic spacer layer is between the  
5 antiferromagnetic layer and the sense layer.

1           8.    The giant magnetoresistive memory device  
2 of claim 7 wherein the magnetic storage layer comprises a  
3 ferromagnetic alloy.

1           9.    The giant magnetoresistive memory device  
2   of claim 7 wherein the magnetic storage layer comprises  
3   ferromagnetic multilayers.

1           10.   The giant magnetoresistive memory device  
2   of claim 1 wherein the antiferromagnetic layer comprises  
3   a first antiferromagnetic layer, wherein the giant  
4   magnetoresistive memory device comprises a second  
5   antiferromagnetic layer, wherein the storage layer is  
6   between the first and second antiferromagnetic layers,  
7   wherein the second antiferromagnetic layer is between the  
8   non-magnetic spacer layer and the storage layer, and  
9   wherein the non-magnetic spacer layer is between the  
10   second antiferromagnetic layer and the sense layer.

1           11.   The giant magnetoresistive memory device  
2   of claim 10 wherein the magnetic storage layer comprises  
3   a ferromagnetic alloy.

1           12.   The giant magnetoresistive memory device  
2   of claim 10 wherein the magnetic storage layer comprises  
3   ferromagnetic multilayers.

1           13. A giant magnetoresistive memory device  
2 comprising:  
3           a magnetic storage layer;  
4           a magnetic sense layer;  
5           a non-magnetic spacer layer between the  
6 magnetic sense layer and the magnetic storage layer;  
7           a first antiferromagnetic layer formed in  
8 proximity to the magnetic storage layer whereby the first  
9 antiferromagnetic layer couples magnetically in a  
10 controlled manner to the magnetic storage layer such that  
11 the magnetic storage layer has uniform and/or directional  
12 magnetization; and,  
13           a second antiferromagnetic layer formed in  
14 proximity to the magnetic sense layer whereby the second  
15 antiferromagnetic layer couples magnetically in a  
16 controlled manner to the magnetic sense layer such that  
17 the magnetic sense layer has uniform and/or directional  
18 magnetization.

1           14. The giant magnetoresistive memory device  
2 of claim 13 wherein the magnetic storage layer comprises  
3 a ferromagnetic alloy.

1           15. The giant magnetoresistive memory device  
2 of claim 13 wherein the magnetic storage layer comprises  
3 ferromagnetic multilayers.

1           16. The giant magnetoresistive memory device  
2 of claim 13 wherein the magnetic sense layer comprises a  
3 ferromagnetic alloy.

1           17. The giant magnetoresistive memory device  
2 of claim 13 wherein the magnetic sense layer comprises  
3 ferromagnetic multilayers.

1           18. The giant magnetoresistive memory device  
2 of claim 13 wherein the magnetic sense layer comprises a  
3 first ferromagnetic alloy, and wherein the magnetic  
4 storage layer comprises a second ferromagnetic alloy.

1           19. The giant magnetoresistive memory device  
2 of claim 13 wherein the magnetic sense layer comprises  
3 first ferromagnetic multilayers, and wherein the magnetic  
4 storage layer comprises second ferromagnetic multilayers.

1           20. The giant magnetoresistive memory device  
2 of claim 13 wherein the storage layer is between the non-  
3 magnetic spacer layer and the first antiferromagnetic  
4 layer, and wherein the sense layer is between the non-  
5 magnetic spacer layer and the second antiferromagnetic  
6 layer.

1           21. The giant magnetoresistive memory device  
2 of claim 13 wherein the storage layer is between the non-  
3 magnetic spacer layer and the first antiferromagnetic  
4 layer, and wherein the second antiferromagnetic layer is  
5 between the sense layer and the non-magnetic spacer  
6 layer.

1           22. The giant magnetoresistive memory device  
2 of claim 13 wherein the first antiferromagnetic layer is  
3 between the storage layer and the non-magnetic spacer  
4 layer, and wherein the sense layer is between the second  
5 antiferromagnetic layer and the non-magnetic spacer  
6 layer.

1           23. The giant magnetoresistive memory device  
2 of claim 13 wherein the first antiferromagnetic layer is  
3 between the storage layer and the non-magnetic spacer  
4 layer, and wherein the second antiferromagnetic layer is  
5 between the sense layer and the non-magnetic spacer  
6 layer.

1           24. The giant magnetoresistive memory device  
2 of claim 13 wherein the first antiferromagnetic layer  
3 comprises first and second storage antiferromagnetic  
4 layers, wherein the second antiferromagnetic layer  
5 comprises first and second sense antiferromagnetic  
6 layers, wherein the storage layer is between the first  
7 and second storage antiferromagnetic layers, wherein the  
8 second storage antiferromagnetic layer is between the  
9 storage layer and the non-magnetic spacer layer, wherein  
10 the sense layer is between the first and second sense  
11 antiferromagnetic layers, and wherein the second sense  
12 antiferromagnetic layer is between the sense layer and  
13 the non-magnetic spacer layer.

1           25. The giant magnetoresistive memory device  
2 of claim 24 wherein the second storage antiferromagnetic  
3 layer is thinner than the first storage antiferromagnetic  
4 layer.

1           26. The giant magnetoresistive memory device  
2 of claim 24 wherein the second sense antiferromagnetic  
3 layer is thinner than the first sense antiferromagnetic  
4 layer.

1           27. The giant magnetoresistive memory device  
2 of claim 26 wherein the second storage antiferromagnetic  
3 layer is thinner than the first storage antiferromagnetic  
4 layer.

1           28. A method of fabricating a giant  
2 magnetoresistive memory device comprising:  
3           forming a non-magnetic spacer layer between a  
4 magnetic sense layer and a magnetic storage layer; and,  
5           forming an antiferromagnetic layer in proximity  
6 to one of the magnetic storage layer and the magnetic  
7 sense layer whereby the antiferromagnetic layer couples  
8 magnetically in a controlled manner to the one of the  
9 magnetic storage layer and the magnetic sense layer such



10 that the one of the magnetic storage layer and the  
11 magnetic sense layer has uniform and/or directional  
12 magnetization.

1           29. The method of claim 28 wherein the  
2 magnetic storage layer comprises a ferromagnetic alloy.

1           30. The method of claim 28 wherein the  
2 magnetic storage layer comprises ferromagnetic  
3 multilayers.

1           31. The method of claim 28 wherein the  
2 magnetic sense layer comprises a ferromagnetic alloy.

1           32. The method of claim 28 wherein the  
2 magnetic sense layer comprises ferromagnetic multilayers.

1           33. The method of claim 28 wherein the  
2 magnetic sense layer comprises a first ferromagnetic  
3 alloy, and wherein the magnetic storage layer comprises a  
4 second ferromagnetic alloy.

1           34. The method of claim 28 wherein the  
2 magnetic sense layer comprises first ferromagnetic  
3 multilayers, and wherein the magnetic storage layer  
4 comprises second ferromagnetic multilayers.

1           35. The method of claim 28 wherein the forming  
2 of a non-magnetic spacer layer between a magnetic sense  
3 layer and a magnetic storage layer comprises forming a  
4 non-magnetic spacer layer between a ferromagnetic storage  
5 layer and a ferromagnetic sense layer.

1           36. The method of claim 28 wherein the forming  
2 of an antiferromagnetic layer in proximity to one of the  
3 magnetic storage layer and the magnetic sense layer  
4 comprises forming the antiferromagnetic layer between the  
5 magnetic storage layer and the non-magnetic spacer layer.

1           37. The method of claim 28 wherein the forming  
2 of an antiferromagnetic layer in proximity to one of the  
3 magnetic storage layer and the magnetic sense layer  
4 comprises forming the antiferromagnetic layer so that the  
5 magnetic storage layer is between the antiferromagnetic  
6 layer and the non-magnetic spacer layer.

1           38. The method of claim 28 wherein the forming  
2 of an antiferromagnetic layer in proximity to one of the  
3 magnetic storage layer and the magnetic sense layer  
4 comprises:

5           forming a first antiferromagnetic layer in  
6 proximity to the magnetic storage layer; and,

7           forming a second antiferromagnetic layer in  
8 proximity to the magnetic sense layer.

1           39. The method of claim 38 wherein the forming  
2 of a non-magnetic spacer layer between a magnetic sense  
3 layer and a magnetic storage layer comprises forming a  
4 non-magnetic spacer layer between a ferromagnetic storage  
5 layer and a ferromagnetic sense layer.

1           40. The method of claim 38 wherein the forming  
2 of a first antiferromagnetic layer in proximity to the  
3 magnetic storage layer comprises forming the first  
4 antiferromagnetic layer so that the storage layer is  
5 between the non-magnetic spacer layer and the first  
6 antiferromagnetic layer, and wherein the forming of a  
7 second antiferromagnetic layer in proximity to the  
8 magnetic sense layer comprises forming the second  
9 antiferromagnetic layer so that the sense layer is

10 between the non-magnetic spacer layer and the second  
11 antiferromagnetic layer.

1           41. The method of claim 38 wherein the forming  
2 of a first antiferromagnetic layer in proximity to the  
3 magnetic storage layer comprises forming the first  
4 antiferromagnetic layer so that the storage layer is  
5 between the non-magnetic spacer layer and the first  
6 antiferromagnetic layer, and wherein the forming of a  
7 second antiferromagnetic layer in proximity to the  
8 magnetic sense layer comprises forming the second  
9 antiferromagnetic layer so that the second  
10 antiferromagnetic layer is between the sense layer and  
11 the non-magnetic spacer layer.

1           42. The method of claim 38 wherein the forming  
2 of a first antiferromagnetic layer in proximity to the  
3 magnetic storage layer comprises forming the first  
4 antiferromagnetic layer so that the first  
5 antiferromagnetic layer is between the storage layer and  
6 the non-magnetic spacer layer, and wherein the forming of  
7 a second antiferromagnetic layer in proximity to the  
8 magnetic sense layer comprises forming the second  
9 antiferromagnetic layer so that the sense layer is

10 between the second antiferromagnetic layer and the non-  
11 magnetic spacer layer.

1           43. The method of claim 38 wherein the forming  
2 of a first antiferromagnetic layer in proximity to the  
3 magnetic storage layer comprises forming the first  
4 antiferromagnetic layer so that the first  
5 antiferromagnetic layer is between the storage layer and  
6 the non-magnetic spacer layer, and wherein the forming of  
7 a second antiferromagnetic layer in proximity to the  
8 magnetic sense layer comprises forming the second  
9 antiferromagnetic layer so that the second  
10 antiferromagnetic layer is between the sense layer and  
11 the non-magnetic spacer layer.

1           44. The method of claim 38 wherein the forming  
2 of a first antiferromagnetic layer in proximity to the  
3 magnetic storage layer comprises forming first and second  
4 storage antiferromagnetic layers in proximity to the  
5 magnetic storage layer, wherein the forming of a second  
6 antiferromagnetic layer in proximity to the magnetic  
7 sense layer comprises forming first and second sense  
8 antiferromagnetic layers in proximity to the magnetic  
9 sense layer, wherein the storage layer is between the

10 first and second storage antiferromagnetic layers,  
11 wherein the second storage antiferromagnetic layer is  
12 between the storage layer and the non-magnetic spacer  
13 layer, wherein the sense layer is between the first and  
14 second sense antiferromagnetic layers, and wherein the  
15 second sense antiferromagnetic layer is between the sense  
16 layer and the non-magnetic spacer layer.

1 45. The method of claim 44 wherein the second  
2 storage antiferromagnetic layer is thinner than the first  
3 storage antiferromagnetic layer.

1 46. The method of claim 44 wherein the second  
2 sense antiferromagnetic layer is thinner than the first  
3 sense antiferromagnetic layer.

1 47. The method of claim 46 wherein the second  
2 storage antiferromagnetic layer is thinner than the first  
3 storage antiferromagnetic layer.